Animal Fat and Oil Research

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Eastern Regional Research Laboratory

IN 1938 Congress enacted legislation directing the Secretary of Agriculture to establish four research laboratories to search for new and wider outlets and markets for farm commodities. As a preliminary step, Congress directed that a survey be made to find out what research was being conducted in these fields, to obtain suggesttions for needed research, and to acquire information that would be helpful in fixing the scope of the research programs of the laboratories. The information gained has served as the basis for our research programs.

More recently, Congress enacted legislation called the "Research and Marketing Act of 1946". which authorized additional research on the ultilization of agricultural commodities.

Administration: The four Regional Research Laboratories are administered by the Bureau of Agricultural and Industrial Chemistry. This Bureau is one of the seven research bureaus which constitute the Agricultural Research Administration. The offices of the Bureau and the Agricultural Research Administration are located in Washington, D. C. G. E. Hilbert is Chief of the Bureau, and P. V. Cardon is the Research Administrator.

Laboratory Locations

Organization: As directed by Congress, one of the four Regional Research Laboratories is located in each of the major farming areas of the United States. The Eastern Laboratory is in Wyndmoor, Pennsylvania, a suburb of Philadelphia; the Northern Laboratory is located in Peoria, Illinois; the Southern Laboratory is in New Orleans, Louisiana; and the Western Laboratory is in Albany, California, in the Bay area.

The commodities assigned for study at the Eastern Regional Research Laboratory are: apples and other deciduous fruits, vegetables, tobacco, milk by-products, potatoes, hides, tanning materials and leather, honey, maple products, wool by-products, of which wool wax or wool grease is most important, and animal fats and oils. The term "animal fats and oils" as used here does not include butter or fish oils, work on these two fats is done by other government agencies.

Animal Fat and Oil Research: Although we have given some attention to problems connected with edible animal fats, particularly lard, most of our research on animal fats and oils is devoted to development of new uses. We are not concerned with service type of work, and in general do not investigate production and processing problems of the fat industry except when successful new uses depend on production of a better basic raw material, or when a promising new product requires the development of a process satisfactory for its production.

Use Fundamental Approach

The major part of the research is basic or fundamental. Undoubedly some feel that this research should be confined to fundamental investigations, but this is obviously not advisable. On the other hand, experience has demonstrated that a rather fundamental approach to the research problems over a reasonable length of time is usually much more productive in developing new uses than is the type thought of as short-term applied research.

Although the Oil and Fat Division is primarily responsible for the work on animal fats and oils, including wool grease, research on these commodities is not confined to this division. The Chemical Engineering and Development Division, headed by R. K. Eskew and the Analytical and Physical Chemistry Division, headed by B. A. Brice, also are making important contributions, Probably about 2 people in the Chemical Engineering Division and 6 in the Analytical and Physical Chemistry Division are working on problems dealing with animal fats and oils.

The present staff of the Oil and Fat Division consists of about 30 people; about 20 have college degrees. The remaining 10 are subprofessional laboratory assistants; several are taking part-time college training. The Division is divided into the following 4 sections, each assigned to a specific field of work and headed by a research leader.

Chemical Modification
J. T. Scanlan (also includes work on wool grease)

Composition and Quality
R. W. Riemenschneider

Surface-Active Agents
A. J. Stirton

Oxidation Products
Daniel Swern

Chemical Modification Section: This section is charged with the major responsibility for preparing chemical derivatives of fats and their constituents, such as the fatty acids, which will have industrial and chemical uses. Thus far the work has been confined chiefly to derivatives prepared by chemical reactions with the unsaturated portion of the molecule, that is, the double bond, rather than with the acidic portion of the molecule —the carboxyl group. Derivations of the latter type are being explored more extensively by industry.

Oleic Acid Research

At an early stage in this research, however, we realized that a chemical processing industry would require starting materials having a higher degree of chemical purity than those generally available from the industrial fat-processing industry. Since the most important single constituent of animal fats is oleic acid, commonly sold as red oil, this has received most of our attention. Red oils of commerce which contain more than about 75 percent oleic acid, regardless of the number of distillations, have not come to our attention. The various industrial refining procedures used, although they improve the color and odor appreciably, do not noticeably increase the oleic acid content.

We are happy to report that we have developed a process for producing an improved technical

grade of oleic acid having a purity (monoethenoic acid content) of 90 percent or more. The process involves removal of the objectionable polyunsaturated components of the fat by selective hydrogenation and subsequent removal of the saturated acids (stearic and palmitic) by crystallization. With the help of the Chemical Engineering and Development group, this product has been made in pilot-plant quantities for sample distribution and evaluation. In response to our published statements of availability, we received about 150 inquiries, 60 of which requested samples for evaluation.

With certain nonessential modifications, this process is now used by one of the larger industrial fat processors, and the improved product has been available commercially for some months. Because the process is so simple and inexpensive, the improved oleic acid is at present marketed at only a nominal premium in price over that of other grades.

Other work, at present only in the laboratory stage of development, includes the preparation of polymerizable derivatives and of various nitrogen derivatives of fatty acids.

Oxidative Derivatives

Oxidation Products Section: The work of this section is concerned exclusively with preparation of oxidative derivatives of fats and their constituents. Already methods have been developed for converting oleic acid into chemical derivatives potentially useful in industry. By one method oleic acid, or a similar compound, can be converted into its epoxy (cyclic ether) derivative, which is especially reactive and can be used in the preparation of polymers or for the addition of long carbon chains to other compounds. A similar method converts oleic acid into dihydroxystearic acid, which offers considerable promise as an intermediate in the preparation of plasticizers and high-melting synthetic waxes. Both methods can be applied not only to oleic acid but to any fat or fatty acid as well as to many other olefinic compounds that contain an isolated double bond.

These methods for oxidizing fats use relatively cheap hydrogen peroxide and give substantially quantitative yields without undesirable by-products. Hence they are suitable for commercial application, and interest has been shown in them by a number of chemical manufacturers. These methods have focused increased attention on fats as possible sources of industrial chemicals.

At present the work of this group is mainly directed toward investigating the possibility of producing valuable chemicals from fats by oxidation in which air or cheap industrial oxygen would serve as the oxidizing agent. Success in this research would not only greatly increase the outlet for fats but would permit producers of the fats to be paid a higher price than might be the case if expensive oxidizing agents were required.

Soap, Detergent Section

Surface-Active Agent Section: This section devotes its attention to soaps, detergents, emulsifiers and similar surface-active agents. What is probably our most important contribution in this field was made during the war years in connection with manufacture of synthetic rubber.

The type of synthetic rubber produced in greatest volume (GR-S) is made by copolymerization of butadiene and styrene while they are emulsified as minute globules in water. During the early years, seriously inconsistent results were obtained in the polymerization process, and it was suspected that the tallow soaps used in preparing the emulsion contained substances that retarded polymerization.

The Eastern Laboratory undertook an investigation of tallow and tallow soaps as a part of the comprehensive research program of the Rubber Reserve Company. A number of universities and several rubber companies and soap manufacturers also participated in this program. These joint investigations succeeded in demonstrating that the polyunsaturated acid content of the tallow soaps was reponsible for the difficulty. As a remedy, it was suggested that the tallow be subjected to mild selective hydrogenation before being used for the preparation of such soap. This treatment has since been used in the preparation of all soap intened for rubber polymerization. In 1946 the soap requirements for synthetic rubber manufacture were about 95 million pounds, but owing to imports of natural rubber and the more recent switch to "cold" rubber, the demand for tallow and grease for this purpose is now considerably lower. Nevertheless, estimated consumption in this field in 1949 was 22 million pounds.

In connection with this problem, the Analytical and Physical Chemistry group have made an important contribution. The spectrophotometric method of analysis developed by them is the only method capable of detecting the polyunsaturated constituents of tallow with the required degree of precision. This method has been adopted throughout the industry for control purposes and for incorporation in the specifications used by Rubber Reserve Company for purchase of soap.
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Other problems which have received considerable attention in this section include: (1) Development of suitable soap or soaplike additives for lubricating oils; (2) use of soaps in organic synthesis such as in the preparation of ester type plasticizers, and (3) preparation and evaluation of various soaps and synthetic detergents made from the fatty acids of tallow.

The properties of the various derivatives of acids found in tallow indicate that there is a possibility of making satisfactory and competitive detergents from tallow or its constituent acid.

Edible Meat Fats

Composition and Quality Section: In this section, work is carried out on lard and tallow as edible products. The importance of the edible meat fats to our national health and economy has received too little recognition. It surprises many to find that our lard production alone is approximately equal to the combined production of both soybean and cottonseed oils.

Research has proved that these fats are high energy foods which contain substances necessary for good nutrition and that they are almost completely digestible. Moreover, all edible fats and oils, whether of animal or vegetable origin, are good ingredients for shortening. However, the need for further research is indicated since none of the natural fats or oils have all the qualities required for all-purpose shortenings.

The most important properties in which improvements should be sought are keeping quality or stability, and such physical characteristics as plastic range, consistency and creaming power, odor,

flavor, color and smoke point. In considering the possibilities for improvement, it is well to keep in mind the fact that greater stability is fundamental. Unfortunately, animal fats do not contain the amounts of naturally occurring antioxidants found it domestic vegetable oils, and without stability other improvements may be of little value, because the best shortening is unfit for use if it has a rancid flavor or odor.

Consequently considerable time has been devoted to the study of antioxidants for use in lard. A few, such as ascorbyl palmitate and lauryl gallate, have attracted some commercial attention. At present, however, the most promising appears to be a mixture of butylated hydroxy anisole, propyl gallate and citric acid. The use of this antioxidant combination in lard was developed in the laboratories of the American Meat Institute. Its effect carries over into finished bakery products to a marked degree. Further improvements in antioxidants seem possible, and our work along these lines is being continued.

Our work on stability has not been confined, however, to the synthesis and study of new antioxidants. Extensive work has been done on the development of more satisfactory methods for evaluating antioxidants and stability of fats. We have succeeded in showing that the polyunsaturated components of fats are chiefly responsible for instability. The role of synergists in fats has been studied, as well as the effect of traces of metals such as iron and copper.

Out of our studies has come a simple method for use by farmers in the preservation of home-rendered lard. The method consists in the addition of about 5 percent of a commercial hydrogenated vegetable shortening to the lard at rendering time. This treatment at least doubles the life of the product.

Considerable work has also been done on determination of the glyceride structure of lard and tallow. Knowledge of this sort is fundamental to the improvement of such properties as plastic range, consistency, and creaming power as well as to the preparation of fats for special uses by fractionation techniques.

The addition of antioxidants and improvement of physical properties, however, must not be considered a cure for all the ills of the lard industry. Better packaging also offers great possibilities, not only for improving the keeping quality but also for increasing consumer acceptance. A large percentage of the lard sold on the retail market is packaged in a cardboard carton, chiefly in the one-pound size. Despite improvements in recent years, this package permits ready contact of air with the contents, and its inconvenience in use is a serious obstacle to consumer acceptance of the product.

Wool Grease Studies

Wool Grease Section: Under the Research and Marketing Act of 1946, funds are available for studies of wool grease aimed at in creasing the outlets for this material. In the past, this potentially valuable by-product has generally been scoured from the wool by aqueous solutions of soap and soda, which were then run to the sewer. For various reasons, including the resulting serious stream contamination, solvent scouring systems, which recover the grease, are receiving favorable consideration. In the United States, a maximum potential recovery of this grease is about one hundred and fifty million pounds per year.

Wool Grease is composed exclusively of what the chemist calls "waxes", that is, esters of higher fatty acids with complex alcohols. Although wool grease has a number of uses, it is best known to the layman as lanolin, a bleached deodorized product used in pharaceuticals and cosmetics. Although this outlet is attractive because of the price obtained for the products, it takes only a small proportion of the total amound available, and it is more or less inelastic.

Attention is being given to the possibility of obtaining useful chemicals or other products from wool grease. Before any substantial progress can be made, however, additional knowledge must be obtained concerning the chemical constituents of wool grease and methods of isolating them. We are working along these lines at present.

Conclusion: It has not been possible in this presentation to give all details of even the most important phases of our work. Moreover, considerable research has been done along some lines not mentioned. Detailed information has been made available in more than seventy published scientific papers as well as in more than thirty patents and patent applications on file. These show that substantial progress is being made along the scientific and technological lines which are fundamental to increased utilization.